

Naval Submarine Medical Research Laboratory

NSMRL Special Report #04-01

05 Aug 2004



**COMMAND HISTORY
OPNAV 5750-1
FISCAL YEAR 2003**

Jerry C. Lamb, Ph.D., and Ellen M. Perkins, Editors

Naval Submarine Medical Research Laboratory
Special Report #04-01

Released by:
G. A. HIGGINS, CAPT, MSC, USN
Commanding Officer
NavSubMedRschLab

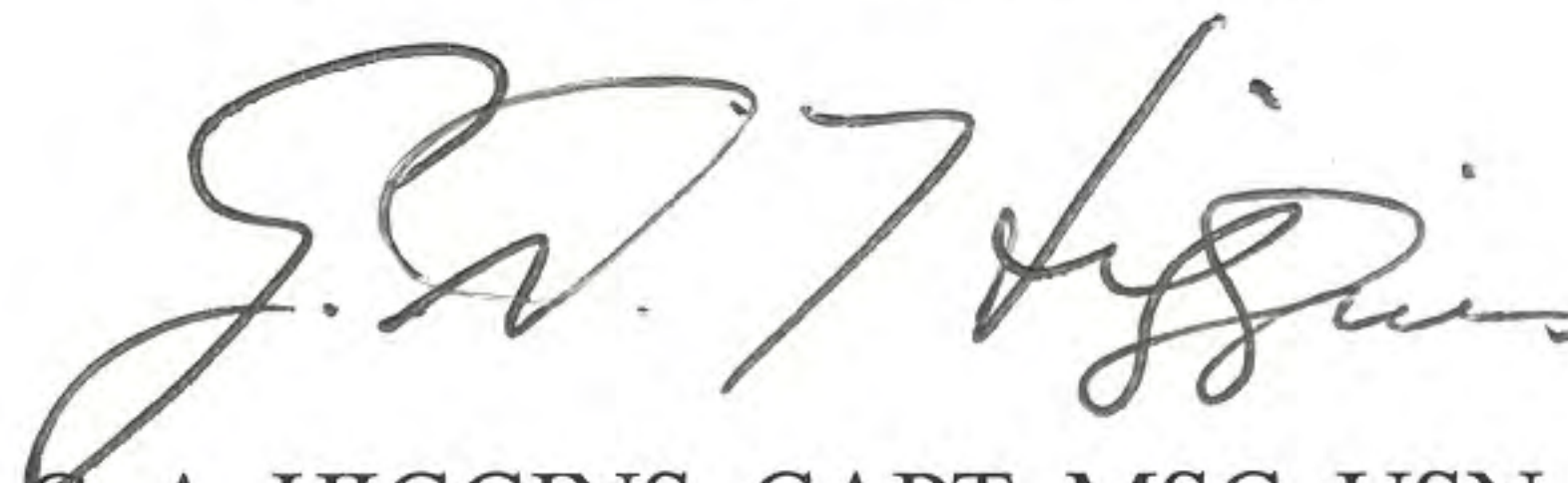
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Approved and Released by:

A handwritten signature in black ink, appearing to read "G. A. Higgins". The signature is fluid and cursive, with the first name "G." and last name "Higgins" clearly distinguishable.

G. A. HIGGINS, CAPT, MSC, USN
Commanding Officer
NAVSUBMEDRSCHLAB

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ABSTRACT

This is the Command History, OPNAV 5750-1, for the Naval Submarine Medical Research Laboratory for Fiscal Year 2003.

ADMINISTRATIVE INFORMATION

This report was approved on September 30, 2004 and assigned Special Report Number 04-01.

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COMMAND HISTORY
Fiscal Year 2003
Part 1

1. Basic Historical Narrative

a. Command Mission

The Naval Submarine Medical Research Laboratory's (NSMRL) mission is to protect the health and enhance the performance of our war fighters through focused submarine, diving, and surface research solutions. Established in World War II, NSMRL was originally responsible for selecting personnel for training at the Submarine School, conducting specialized training in submarine medicine for Hospital Corpsmen and Medical Officers, and researching medical aspects of submarines and diving. Today, NSMRL continues to be the biomedical R&D leader in submarine medicine, health effects of submarine atmosphere constituents, auditory sonar information processing, selection/qualification of submariners, escape and rescue from disabled submarines, diving bioeffects, and hearing conservation technology.

b. Command Staff

Commanding Officer: CAPT G. A. Higgins, MSC, USN

Executive Officer: LCDR R. K. LeBlanc, MSC, USN

Technical Director: Jerry C. Lamb, Ph.D.

Departments:

Submarine Medicine & Survival Systems	CDR W. G. Horn, MC, USNR
Diving & Environmental Simulation	E. A. Cudahy, Ph.D.
Human Performance	CDR K. S. Wolgemuth, MSC, USN
Resources	HMCS(SS) S. Plourd, USN

Immediate Superior in Command: CAPT James T. Luz, MSC, USN,
Commanding Officer, Naval Health Research Center, San Diego, CA.

c. Facilities:

(1) Located on the Submarine Base New London, Groton, CT, NSMRL researchers have access to three Attack Submarine Squadrons in Submarine Group Two, the Naval Submarine School, the Naval Submarine Support Facility, the Naval Undersea Medical Institute, and many more submarine support activities. One mile down the Thames River is the Electric Boat Division of General Dynamics, builder of all classes of U.S. nuclear submarines. Several colleges and universities are nearby, including the U.S. Coast Guard Academy, Connecticut College, and the University of Connecticut. NSMRL's three multi-disciplinary research departments use highly capable facilities

including three hyperbaric chambers, anechoic chambers, auditory and vision laboratories, closed atmosphere test room, diving boat, technical library, and Dodge Pond Open Water Diving and Sonar Test facility.

(2) Capabilities:

- 3 Hyperbaric Chambers (1 Saturation/Hyperbaric/Hypobaric)
- 1000m³ Anechoic Chamber
- 140m³ Reverberant Chamber
- 10 Audio Testing Booths
- Vision Research Suites
- Closed Atmosphere Test Room
- Diving Work Boat
- Technical Library

(3) Floor Space:

- Building 148 - 6,480 sq ft
- Building 141 - 19,930 sq ft
- Building 156 - 17,952 sq ft

d. Mission Accomplishments by FY03 Research Work Units.

Submarine Medicine & Survival Systems Department
W.G. Horn, CDR, MC, USNR, Department Head

Work Unit #5403

Title: Study on Prediction of Submarine Service Disqualifications

Principal Investigator: M. N. Bing, Ph.D.

Accomplishments (FY03): In FY03 the SUBSCREEN profile reports were modified such that the probability of disqualification and separation, provided by the SubMarine Attrition Risk Test (SMART, formerly known as SARS), was added to the reports. The probability of disqualification and separation provided by the SMART is now used as a decision aid by the mental health status interviewers to reach a final disposition on BESS students who are referred to the Mental Health Clinic on the basis of SUBSCREEN referral criteria. Also in FY03 a new referral rule was added to the SUBSCREEN screening process. Specifically, BESS students identified by the SMART as having an 80% or greater probability of negative fleet attrition are now referred to the Mental Health Clinic for a mental health status interview. These improvements should lead to fewer psychological disqualifications and fewer psychologically based medical evacuations (MEDEVACS) in the Submarine Fleet operations.

Work Unit #5602

Title: Submarine Escape and Rescue

Principal Investigator: W. G. Horn, CDR, MC, USNR

Accomplishments (FY03): This NSMRL project was initiated to identify food, water, clothing and lighting necessary to sustain survival and perform escape or rescue actions in disabled submarine (DISSUB) scenarios.

- Food: Collaboration with the US Army Research Institute of Environmental Medicine (USARIEM) resulted in the identification of Meals Ready to Eat (MRE) as the optimal aft compartment food item.
- Water: Collaboration with COMNAVSEASYSCOM engineering staff indicates that potable water in DISSUB scenarios should be readily available.
- Clothing: Given the SURVIVEX 2003 findings of warm temperatures in cold water, the need for stowing clothing is problematic. Further work on this project is held in abeyance pending results of SURVIVEX 04.
- Lighting: Several lighting techniques were evaluated during SURVIVEX 03. Six-inch green chemical lights (Cyalume sticks) proved adequate to illuminate vital areas. LED flashlights were also adequate. Both the chemical lights and LED lights were subjected to pressure testing. Chamber testing of the chemical lights revealed ability to withstand 132 feet of sea water but did not withstand pressurization to 600 fsw which is the maximum pressure in the escape trunk during escape. Diving LED flashlights tested did withstand pressure testing to those depths.

These findings have been presented to COMNAVSEASYS COM, COMSUBDEVRON 5 and the Submarine Escape and Rescue Working Group.

Work Unit #5708

Title: Submarine Atmosphere Health Assessment Program (SAHAP)

Principal Investigator: W. G. Horn, CDR, MC, USNR, S. DiNardi, Ph.D., and R. Woolrich

Accomplishments (FY03): During FY03 SAHAP has continued to perform air sampling onboard submarines deploying in excess of 28 days. Not all submarines are visited by SAHAP personnel due to limited funding; however, a representative sample of East and West Coast submarines, both SSN and SSBN, are sampled. During FY03, a total of 10 submarines were visited and atmosphere sampling was achieved.

As well as achieving sampling onboard 10 deploying submarines, SAHAP was also able to continue validation testing of new passive monitoring media against the 'gold' standard of active monitoring. Monitoring of particulates in the submarine atmosphere, including monitoring for ultra fine particles, continued throughout the year.

Work Unit #5903

Title: Prediction and Prevention of Submarine Service Disqualifications

Principal Investigator: M. N. Bing, Ph.D.

Accomplishments (FY03): All data have been entered into the SUBSCREEN Disqualification Database and, for this retrospective study, data preparation have been completed. Findings indicate that SUBSCREEN is a significant predictor of disqualification from the submarine force after completion of Basic Enlisted Submarine School (BESS). Statistical analyses revealed that a discriminant function based on optimally predictive SUBSCREEN subscale scores successfully categorized 60.1% of those screened into one of two groups, successful vs unsuccessful submariners, using a cross-validated grouping procedure (i.e., jackknife procedure). For these analyses, successful service in the submarine force was defined as follows: BESS students who had taken SUBSCREEN and were currently on active submarine duty, had a least four years of service, and had reached and remained at the rank of E4 or higher. Unsuccessful service was defined as follows: BESS students who had taken SUBSCREEN and subsequently disqualified and separated from the Navy for negative reasons (e.g., misconduct) prior to the 49th month of service, and had an average rank of E2, with a maximum of E4.

In FY03, the SUBSCREEN profile reports were modified so that the probability of negative separation, provided by the discriminant function, is now printed on the report. This function has been labeled the Submarine Attrition Risk Test (SMART). The probability of disqualification provided by the SMART is now used as a decision aid by the mental health status interviewers to reach a final disposition on BESS students who are referred to the Mental Health Clinic on the basis of SUBSCREEN referral criteria. Therefore, the research of Phase I has been transitioned into a product, SMART that is now currently being used by the Navy to identify submariner trainees that are at risk

for early and negative attrition, and may be unsuitable for submarine service. The SMART was also cross-validated on attrition indicators that occur prior to fleet duty. The SMART predicts which prospective submariners are likely to receive non-judicial punishment while at BESS, and it also predicts which prospective submariners are likely to end up in a legal hold status during submarine training or while awaiting transfer (AWT).

Phase II, in which a clinical inventory other than SUBSCREEN was administered with the aim of identifying traits that can improve upon the prediction of disqualification from the submarine service, has been partially completed. Specifically, data collection with the MCMI-III has been completed, and data preparation and analyses are ongoing. The MCMI-III was administered to approximately 1440 submariners serving on SSNs and SSBNs in SUBLANT. Preliminary analyses have been completed for the scales. Early results indicate that SSN service leads to higher anxiety levels and depression when compared to SSBN service. The MCMI-III has also been administered to approximately 1121 BESS students, and data collection on fleet disqualification and separation information for those students is still ongoing.

Also in FY03, the PIs gave presentations to military and professional personnel regarding the implications of this project for improving the psychological screening of prospective submariners, and the subsequent performance of the Submarine Fleet.

Work Unit #50202

Title: Feasibility of Using Hand-Held Personal Digital Assistants (PDAs) in a Hyperbaric Environment and the PDA-based Submarine Escape and Rescue Calculator and Information Library (SERCIL)

Principal Investigator: W. G. Horn, CDR, MC, USNR

Accomplishments (FY03): This NSMRL project was initiated to develop PDA software programs that would perform calculations and provide guidance for the senior survivor in a disabled submarine (DISSUB), and test the ability of the PDAs to perform under hyperbaric conditions that might develop in a DISSUB.

The initial testing involved chamber testing of the Palm Vx model PDA. This device successfully operated at pressures up to 132 feet of seawater, with a chamber diver able to perform calculations at that pressure. This included scribing data on the contact screen and reading results from formulae calculations after data entry. Further chamber testing demonstrated the ability for other models, including the Sony Clio, Hewlett Packard Jornada, Palm VIII, Palm III, and other models to perform at a pressure equivalent to 132 feet of sea water.

Following successful pressure testing, software development was initiated, incorporating guidance and formulae in the submarine class Senior Survivor Guides (Guard Books) into the program. This program was Palm OS system-based, in view of the ambiguity of Palm PDAs on board submarines and the issuance of a Palm Vx PDA to graduates of the Submarine Advanced Officer Course at the Naval Submarine School.

Software programming was successfully developed for the SSBN 726, ballistic missile class submarine, and an emulator version was demonstrated to the Deep Submergence Biomedical Review Group and the CNO N77 Submarine Escape and Rescue Working Group.

The PDA program, entitled Submarine Escape and Rescue Calculator and Information Library (SERCIL) has four major components:

- An algorithm providing step-by-step emergency actions. These are actions that must be immediately performed in a submarine sinking.
- A calculator with built in formulae that calculate time-to-escape.
- An escape vs. wait rescue decision guide.
- A library consisting of the Guard Book, a first aid guide, and Chapter 13 of the Nuclear Powered Submarine Atmosphere Control Manual.

Currently, the software programs for the various submarine classes are 90% complete. Further programming was held in abeyance in light of the major revisions to the Guard Books as a result of SURVIVEX 2003. Funding has been reserved for completion of software development.

Work Unit #50210

Title: Submariner Bone Turnover and Vitamin D Supplementation

Principal Investigator: E. Harris, LT, MC, USN

Accomplishments (FY03): Plasma levels of 25-hydroxycholecalciferol, 1,25-dihydroxycholecalciferol (Vitamin D), calcium, parathyroid hormone, phosphate, osteocalcin, and bone specific alkaline phosphatase, as well as urine levels of N-telopeptide, were examined in 51 submariners aboard a U.S. Navy Fleet Ballistic Missile Submarine (SSBN). These levels were obtained before leaving on a 76-day deployment; at the start (deployment day 49) of a 6-day mid-patrol liberty period, at the end of the liberty period, and upon return to homeport. Twenty-six of the subjects received oral vitamin D supplementation during the patrol and 25 received an identical appearing placebo. Both groups showed significant reduction in 25-hydroxycholecalciferol and 1,25-dihydroxycholecalciferol levels during the first portion of the patrol, but recovered quickly during the liberty period, and finished the patrol with normal levels. Indicators of bone turnover showed an increase in activity toward the end of the patrol in both groups, while serum calcium levels were maintained within normal limits throughout. These findings indicate that supplementation with oral vitamin D does not maintain serum vitamin D levels in submariners, and that six days or less of sunlight exposure are adequate to return these values to baseline.

Our study results support previous work demonstrating significant drops in serum vitamin D levels in submariners while underway. However, because vitamin D and bone metabolism markers stayed within normal limits at all times, we believe that the changes we saw, though sometimes statistically significant, are not clinically relevant. Surprisingly, we found that oral vitamin D supplementation at the USRDA dosage does not seem to prevent statistically significant drops in serum

vitamin D levels. The results also show that healthy individuals demonstrate an impressive ability to replenish vitamin D stores to pre-deployment levels within a few days of re-exposure to sunlight.

A report on the results of this work is currently in the final stages of publication.

Work Unit #50301

Title: Testing and Evaluation of a Low Cost Retractable Needle Safety Syringe for Naval Health Care

Principal Investigator: D. Watenpugh, Ph.D.

Accomplishments (FY03): Representatives from Safety Medical International (SMI), NSMRL, and Dr. Ed Marcinik held kickoff meetings in November 2002. We identified specific objectives and developed a research plan which culminated in the proposal for Congressional funding. NSMRL produced our component of the project proposal, edited the SMI sections of the proposal, and finalized and submitted the funded version in January 2003. Funding for this project arrived at NSMRL on 5 March 2003, and GSA awarded the contract to SMI on 11 March 2003. NSMRL assembled its research team and proceeded with syringe evaluation preparations, including development of a detailed testing and evaluation plan, IRB protocol preparation, and requirements, design and construction of a controlled temperature enclosure for environmental testing. Temperature and pressure limits for operationally relevant environmental simulation for syringe testing have been established.

In August 2003, GSA accepted an SMI request for a 2-month delay of syringe manufacturing and delivery due to technical challenges. NSMRL completed construction and began testing of the controlled temperature enclosure. SMI is due to deliver their first required report of SMI internal syringe evaluation and demonstration syringes to NSMRL in October 2003 (FY04).

Work Unit #50303

Title: Pulmonary Function Screening of Submarine Personnel Prior to Pressurized Submarine Escape Training and Development of Lung Function Standards

Principal Investigator: P. Benton, Surgeon Commander, Royal Navy

Accomplishments (FY03): A Human Use Protocol was submitted and approved by the NSMRL Institutional Review Board in December 2002. Spirometers and associated data collection software have been identified and the procurement process has been initiated. In May 2003, the first spirometer and associated data collection software was delivered. Also in May 2003, a progress report was delivered at the NAVSEA/ONR meeting in Panama City, FL. In June, a small pilot study was undertaken to identify any problems with spirometer compatibility, data collection software, and questionnaire acceptability. In July 2003, procurement of a second spirometer and associated hardware was initiated. Permission was granted by the Commanding Officer, Naval Submarine School, in August 2003, to use students as subjects.

Work Unit #50304

Title: At-Sea Trials of NAVAL Submarine Medical Research Laboratory (NSMRL)
Watchstanding Regimen

Principal Investigator: J. Dyche, LT, MSC, USNR and W.G. Horn, CDR, MC, USNR

Accomplishments (FY03): Materials have been collected in support of this project. The Naval Postgraduate School is assisting with data collection. RADM Tracy has been briefed and has offered full support in assisting the recruitment of four (4) submarines as the protocol specifies. TYCOM Medical Officers are also assisting. The first submarine is expected to be ready by July, with additional submarines following shortly thereafter.

Work Unit #50307

Title: A Trial of Survival Capabilities Aboard a U.S. Navy Simulated Disabled Submarine

Principal Investigator: W. G. Horn, CDR, MC, USNR

Accomplishments (FY03): SURVIVEX 2003, the first survival exercise ever conducted on board a U.S. Navy Submarine, was performed on the USS DALLAS (SSN700) on 15-18 March 2003 pier side at the Naval Submarine Base New London. A total of 94 subjects participated, comprised of 83 submariners and 11 investigators, observers, and monitors. The exercise went to the complete 72-hour goals with no medical casualties resulting from the test conditions.

A number of important findings and conclusions resulted from this exercise:

- The passive CO2 scrubbing curtains successfully maintained CO2 levels within test conditions. The crew demonstrated the ability to safely and effectively assemble and distribute the curtains throughout the submarine.
- No "pocketing" of abnormally low or high levels of CO2 or O2 developed in the submarine compartment during the exercise. The submarine atmosphere stayed fairly uniform and breathable in all spaces.
- Portable gas analyzers were effective in accurately monitoring submarine atmosphere gas levels and clearly superior to other methods.
- Onboard stores of food and water were adequate for survival in the forward compartment. Written guidance for the senior survivor in DISSUB scenarios is inadequate. As a result of the exercise lessons learned, this guidance has been revised and will be distributed to the Fleet in FY04.
- Unexpectedly, temperatures rose in the boat despite the cold ambient winter conditions. This will be investigated in future exercises and has prompted planning for potential heat stress conditions.

The results of this exercise were briefed to COMNAVSUBFOR, Naval Reactors, the Deep Submergence Biomedical Review Group, the CNO Submarine Escape and Rescue Review Group, and the NATO Submarine and Rescue Working Group.

Diving & Environmental Simulation Department
E. A. Cudahy, Ph.D., Department Head

Work Unit #5906

Title: Effects of Low-Frequency Waterborne Sounds on Divers

Principal Investigator: E.A. Cudahy, Ph.D.

Accomplishments (FY03) The general purpose of this research is to develop a theoretical and empirical basis for assessing health risks accompanying exposure to low-frequency waterborne sound. The objectives are to quantify the effects of low-frequency sound on hearing, vibrotaction, pulmonary function, and cardiovascular function.

Work Unit #50003

Title: Loudness Mapping for Underwater Sound from 100-50,000 Hz

Principal Investigator: E. A. Cudahy, Ph.D.

Accomplishments (FY03):

- Phase 1 - Thresholds were measured from 25 Hz to 32,000 Hz for a single one-second signal. A loudness contour was measured for a single intensity of standard.
- Phase 2a - thresholds were measured for 100 - 16,000 Hz and loudness contours measured for six intensities of standard.
- Phase 2b - Thresholds and loudness contours (for two intensities of standard were measured for 100 - 16,000 Hz signals. Signal duration was varied from 20 milliseconds to 5 seconds.
- Phase 3 - Loudness contours were measured for tonal and noise signals with different frequency spectra. The threshold measurements were the first data to verify that human divers can hear tones above 20,000 Hz underwater. The threshold and loudness contours were flattened at the low frequencies, especially at 50 Hz. This is also a new finding and is tentatively attributed to lung resonance effects. All divers reported feeling vibration at the lower frequencies. The loudness contour was flatter across frequency than the threshold function and suggests that the dynamic range is more compressed at the highest frequencies than at the lowest frequencies. Duration effects were greatest at 100 Hz and 16,000 Hz. We are currently relating the relative loudness of the complex signals to the loudness contours measured during Phase 2.

The results of this work were briefed at the ILIR review in December 02. An NSMRL Technical Report and Peer Review article have been initiated.

Work Unit #50201

Title: Underwater and Dive Station Work-Site Noise Survey

Principal Investigator: E. A. Cudahy, Ph.D.

Accomplishments (FY03): In-water and in-air noise measurements were conducted on dive station in San Diego Harbor (Navy Public Works Divers), the USS MONITOR gun turret recovery (MDSU2), USS ARIZONA hull integrity study (MDSU1 and National Park Service), Navy Diving and Salvage Training Center (Underwater Construction Divers of U.S. Navy and U.S. Army), and at the NOAA Aquarius Undersea Laboratory where Navy Divers regularly work as volunteers.

Permissible exposure levels were calculated on-site for non-Navy approved tools used both during the USS MONITOR gun turret salvage job (20K psi hydro blaster at 230 feet of sea water) and the USS ARIZONA hull integrity study (hydraulic drill press hull core sample extractor). These calculations allowed for enhanced occupational safety procedures for Navy divers.

Presentations were provided at the NSMRL Fleet Review in 2003 and the Navy Occupational Health and Preventive Medicine Conference in 2002. Data analyses and the background and methods section of an NSMRL Technical Report have been initiated.

Work Unit #50204

Title: Guidance and Protection for Exposure to Ultrasound

Principal Investigator: E. A. Cudahy, Ph.D.

Accomplishments (FY03):

- Measurement of open ocean sound attenuation for wetsuit hood
- Measurement of high frequency thresholds to 190 kHz
- Fleet guidance provided for several new sonar systems
- Sonar test and evaluation programs have all been accomplished.

Work Unit #50205

Title: Underwater Impulse Noise Protection

Principal Investigator: E. A. Cudahy, Ph.D.

Accomplishments (FY03):

- First quantitative test of human perception of underwater impulse noise.
- First quantitative test of wet suit attenuation
- Underwater impulse sound field developed for impulse noise parameters
- Preliminary data analyses have shown that threshold and loudness are dependent on the rise/fall time of the impulse.
- A technical report on this project has been initiated.

Work Unit #50206

Title: Effects of Carbon Dioxide and Oxygen Levels on Auditory Sensitivity and Frequency Tuning Curves

Principal Investigator: K.S. Wolgemuth, CDR, MSC, USN

Accomplishments (FY03): Non-commercial stimulus frequency otoacoustic emissions (SFOAE) hardware (probe delivery system) and software allowed a more sensitive assessment of inner ear performance, which included estimations of auditory filter bandwidth in addition to otoacoustic emission amplitudes. The system also was characterized by a noise floor of approximately -20 dB, superior to what is typically obtained with commercial otoacoustic emission systems. Calibration of the test stimuli in the ear canals of subjects and test-retest variability of SFOAEs assessed in human subjects were more than adequate. To date, 310 SFOAE tests, 38 tympanograms, and 18 audiograms have been performed for 5 pilot and 10 experimental subjects. Each experimental subject serves as own control. Data analyses are ongoing.

Work Unit #50207

Title: Mechanisms to Improve Nitrogen Elimination and Reduce the Incidence of Altitude Decompression Sickness

Principal Investigator: D. Fothergill, Ph.D.

Accomplishments (FY03):

- Performed a theoretical evaluation of the utility of degassed liquids to prevent/treat decompression sickness.
- Designed a work plan to ascertain the best strategy for optimizing N₂ elimination rates using LBPP, negative pressure breathing and exercise.
- Received IRB human use approval for a protocol to test the first two hypotheses in the work plan.
- Researched and purchased hardware for measurement of cardiac output and limb blood flow measurements.
- Developed a reliable technique for measuring arm and leg blood flow and began pilot testing for experiment one.
- In an effort to reduce the reflex bradycardia and increase cardiac output during LBPP, we requested a change to the IRB protocol in February 2003. The changes were made to the protocol and approved by NSMRL's IRB.
- Conducted and completed first phase of experiment one. Twelve subjects participated and results are currently being analyzed.
- Presented progress and provisional findings at the Annual NAVSEA Deep Submergence Biomedical Development/ONR Undersea Medicine Progress Review held at Florida State University, Panama City, FL.
- Briefed the research program at the Fleet Review, Naval Submarine Base New London, July 2003.
- Conducted repeated LBPP measurements on 9 subjects to assess the repeatability of the impedance techniques for measuring relative changes in cardiac output, and limb blood flow during LBPP.
- Developed, built, and tested a neck pressure device for experiment 1B.
- Conducted Experiment 1B.

Work Unit #50212**Title:** Underwater Sound Localization**Principal Investigator:** E. A. Cudahy, Ph.D.

Accomplishments (FY03): The first phase of testing at 100 - 4000 Hz was completed. The minimum audible angle was measured. The data show that divers can localize underwater sound and that performance will improve even through informal training. Divers were consistently able to localize sound at an angle of 10° at 200 Hz with the second of two sets of divers performing best. Divers were also able to localize sound at other frequencies within the test range, but the minimum audible angles were greater.

Work Unit #50308**Title:** Non-Lethal Bioeffects of Underwater Sound [non-lethal bioeffects]**Principal Investigator:** E. A. Cudahy, Ph.D.

Accomplishments (FY03): This project began in March of 2003. The projector and test site selections have been confirmed. The Institutional Review Board has approved the human use protocol and data collection is underway.

The data being collected represent the first quantitative measurement of vibration sensation in divers for underwater sounds from 20 - 100 Hz. Preliminary data suggests that duration is an important parameter for vibration sensation with a significant decrease in vibration threshold as duration is increased.

In addition to the duration parameter, the effects of a wet suit on vibration threshold are being investigated. This study will also collect further data on the lung resonant frequencies of divers as a function of depth. This is critical for determining the variability of diver lung resonant frequencies. This variability and the effects of frequency on vibration threshold will allow assessment of the opportunity to provide non-lethal deterrence using underwater low frequency sound. If the variability among divers is large and the vibration sensation narrowly focused around the resonant frequency, then it will be difficult to design a non-lethal deterrent using this approach. A narrow range of resonant frequency will be offering a much higher probability of success. Success may also be possible if the vibration sensation is broadly focused such that variability in lung resonant frequency does not restrict the impact of the low frequency sound. The current data collection will provide these answers.

Human Performance Department
K.S. Wolgemuth, CDR, MSC, USN, Department Head

Work Unit #50106

Title: Audio Technology & Management in Modern Navy Systems

Principal Investigator: T. P. Santoro, Ph.D.

Accomplishments (FY03): Experiments were designed and carried out in FY03 to determine effects of spatialized audio presentation mode on passive sonar listening. Results support the use of up to seven simultaneous audio channels for the purpose of recognition of well-known sonar transients in the presence of typical conditions and transient distracter sounds. This completes the work plan for this study. A new start proposal has been submitted to ONR Code 342.

Work Unit #50211

Title: Advanced Binaural Displays for Collision Avoidance in Close-In Undersea Environments

Principal Investigator: J. S. Russotti, M.S.

Accomplishments (FY03): To generate the necessary perceptual characteristics essential for the binaural display, a breakthrough beam-forming process was developed that formed beams from a simple linear hydrophone array which were focused at two different distances but in the same direction.

Spatial Vernier Beamforming (SVBF) processing was completed on a database of 15 representative acoustic sonar targets using innovative beam-forming algorithms that maximize the degree of cross-correlation between two overlapping beams. Due to the unique nature of the processed binaural signals, a totally revised test procedure had to be devised for signal presentation and testing. The test procedure required windows based software development, converting algorithms originally based in MS-DOS with significant refinements added. All target signals (normal and experimental) have been "beamform" processed and loaded into digital storage for presentation. Data collection algorithms are currently being tested using the appropriate target test files. The SVBF processing is currently under consideration for application in unmanned undersea vehicle (UUV). The SVBF dual beam data is also ideal for adaptive signal processing, since the noise common to the two beams can be mathematically removed to expose the target.

The SVBF process can easily be adapted for advanced automated signal processing that is modeled from binaural perception. The advantage is real-time processing and, therefore, better detection of transients.

Work Unit #50213**Title:** Sonarmen Earcup Technology**Principal Investigator:** J. S. Russotti, M.S.

Accomplishments (FY03): The research assessed a prototype DNR insert earphone device, with in-ear 2-way communications that, with minor modifications to improve frequency response can meet sonar operator passive listening requirements. The contractor provided two Earcom units (vice one as originally contracted) for a more representative evaluation of frequency response characteristics by NSMRL. These response characteristics will appropriately serve as a baseline performance database. Noise attenuation measurements show the prototype capable of greater than 32dB reduction in airborne sound in 1/3-octave bands from 50Hz to 10kHz. This was achieved through microprocessor-controlled digital noise reduction, without the further application of onboard ANC. Frequency response, while adequate for speech, needs to be upgraded for use by sonar operators as was done on several ANC headsets. Given the capabilities of digital processing, this is a minor, though critical, issue. Report completed. NSMRL Technical Report has been published.

Work Unit #50214**Title:** Human Performance Modeling of the MMWS Build 2 Workstation**Principal Investigator:** T. P. Santoro, Ph.D.

Accomplishments (FY03): Three different GOMS model teams were built to represent three distinctly different workload and communications styles observed in human Air Defense Warfare teams. Predictions of the team models were shown to provide reasonable latency and task duration time estimates to actual team performance when analyzed with the Queuing Theory technique.

Several iterations of the Land Attack Warfare HCI have been simulated in keeping with the development of the LAW Rapid Prototype (RPT) Simulation built by SPAWAR. The latest GOMS model reflects the RPT of August 2003 and will be presented as part of the SPAWAR development program demonstration in the November, 2003 year-end review. It predicts performance of a single operator managing multiple electronic strike packages in a scenario with realistic time requirements and fault events. The scenario will be tested on individual LAW operators using the RPT watch station and their task execution latencies and workload will be compared to the GOMS model prediction.

Funding for further work on the SPAWAR program is uncertain at this time. However, plans do exist for extension of the individual model to a 4-man team and prediction aspects of communications and workload sharing during typical LAW scenarios. NSMRL Technical Report has been published.

Work Unit #50302**Title:** USS VIRGINIA Crew Performance**Principal Investigator:** K. Shobe, LT, MSC, USNR

Accomplishments (FY03): In this one-year project, NSMRL performed various analyses and/or exploratory work that will impact on the development and/or on-going improvement of submarine habitability and safety. A detailed examination and analysis of all aspects of habitability on the VIRGINIA class submarine was conducted expanding upon the work done during OT-IIB. Key areas of concern are ALL berthing spaces, sanitation spaces, crew's mess, chief's quarters, wardroom, control room, and torpedo room as they are assembled in both shipyards. NSMRL Technical Report has been published.

Work Unit #50305**Title:** Working Memory Components of Situation Awareness and Their Relation to Expert Performance**Principal Investigator:** K. Shobe, LT, MSC, USNR

Accomplishments (FY03): Developed the appropriate working memory (WM), long-term working memory (LTWM) and situation awareness (SA) task for the submarine environment that generalize to operational tasks. This was accomplished by conducting directed interviews with subject matter experts and consulting relevant operating doctrine publications. Based on the result of this analysis, these tasks were generated:

- Domain-specific working memory task: Developed a spatial, verbal, and a combined spatial/verbal domain-specific WM task. In order to establish the validity of this task, a pilot study was conducted with 12 submarine officers (O3's) to compare performance on the standard domain-general WM task with the submarine-specific WM task. WM span scores for the submarine-specific tasks correlated strongly with the domain-general scores. Based on these results, we are confident that we have developed a valid submarine-specific WM task.
- Long-term working memory task: Based on the input of the SME's, we decided to use the ship control panel as the platform to measure LTWM. The ship control panel displays depth, speed, course, rudder, and the stern and fairwater planes. First, encoding in and retrieval from long-term memory was tested after a 30-second delay. A pair of consecutive snapshots was shown for 40 seconds and then removed from the screen. The delay period was filled with an intervening task to clear short-term storage of scanned situational information (counting backward by three as fast as possible). After the 30-second delay filled with the intervening task, participants recalled the situation by manually filling in the indications on a sheet of paper where all the indications were blank. The choice of the snapshot (top or bottom) to be reconstructed was randomly selected. Second, construction of retrieval structures was assessed by presenting participants with both meaningful (e.g., plausible real state_ and non-meaningful display situations. For the meaningful situations, each snapshot displayed a routine ship control situation and the pair of snapshots in sequence depicted consecutive routine ship control situations. The snapshot presented at

the top of the screen showed the initial state of the submarine prior to making any control movement. The snapshot presented on the bottom of the screen showed an approximated 4-5 minute later state of the submarine after applying one or two control movements to the top snapshot. For the non-meaningful situations, each snapshot displayed an implausible contact situation that submariners would never encounter, and the pair of snapshots will not depict consecutive ship control situations.

- Situation awareness task: The SA task was also instantiated via the ship control panel displays, and is designed to tap into the three components of SA (the ability to perceive information across multiple sources, to integrate a variety of perceived information to make a coherent mental representation of the current situation, and to project the status of the submarine in the near future). Participants viewed consecutive displays that showed a goal description and two consecutive screens, and then judged whether the submarine depicted by the consecutive snapshots will reach the specified goal state in the next 4-5 minutes. To successfully perform this task, participants had to perceive changes in situation elements across various portions of the display, interpret and understand their meaning, and predict their future implications given the goal state in mind. This provided criterion measures of complex task performance by asking novice and expert operators to perform these tasks, as measured by accuracy and latency.

Work Unit #50306

Title: Advanced Electronic Stethoscope for General Field Use – Final Product Field Testing

Principal Investigator: J. S. Russotti, M.S.

Accomplishments (FY03): Preliminary results show that with the noise reduction (NR) stethoscope, abnormal heart sounds can be detected on average at over 101 dB SPL when used in a sound field that accurately recreates the patient area inside a HumVee ambulance. In that same environment using the NR stethoscope, normal breath sounds are audible at 97 dB SPL vs 88 dB SPL for a normal (Littman Classic) stethoscope. Previous research measured the level inside the patient area at 97 dB SPL which is well above the levels at which a conventional stethoscope is useful. At a recommended 25-foot distance from a field hospital generator, average airborne sound levels of SPL are encountered. The NR stethoscope detected all of the visceral conditions at well above that 90 dB level. Of relevance is the increased speed that detections could be made using the NR device. It should be noted that these results were from highly trained medical listeners with years of experience using the conventional stethoscope and under one hour experience using the experimental device. Optimized performance with the novel device is anticipated after longer use. In that light, results obtained from this simple NR device are highly positive for use in applications where moderately high environmental noise is commonly encountered. Externally, the NR stethoscope appears identical in form and function it works better in operational environments.

Work Unit #50309**Title:** Evoked Otoacoustic Emissions in Military Hearing Conservation Programs**Principal Investigator:** L. Marshall, Ph.D.

Accomplishments (FY03): A manuscript on NSMRL Longitudinal Otoacoustic Emissions Project was accepted for publication in the International Journal of Audiology. A manuscript on NSMRL TTS experiments (“A comparison of transient-evoked and distortion-product otoacoustic emissions following short-duration noise exposure in humans”) was submitted to the International Journal of Audiology. A first draft of a large-scale study (>400 subjects enrolled) on Navy aircraft-carrier personnel was written, but further data analyses were needed and are being completed. Data analyses from another large-scale study (>300 subjects enrolled) on Marine recruits was essentially completed, and an abstract has been written for submission to the spring Acoustical Society of America meeting.

A prototype stimulus-frequency otoacoustic-emission (SFOAE) and transient-evoked otoacoustic-emission (TEOAE) measurement system (along with previously developed distortion-product otoacoustic emissions, or DPOAEs) was delivered by our subcontractor, Mimosa Acoustics, and tested by NSMRL. In so doing, Mimosa Acoustics resolved two major technical problems, one of which resulted in a major improvement for in-the-ear calibration of transient stimuli. A prototype system to measure contra lateral suppression most recently was delivered by Mimosa Acoustics.

NSMRL helped Mimosa Acoustics write a successful NIH-NIDCD SBIR grant to combine reflectance and DPOAE instrumentation. This development will be helpful for our hearing-conservation application, but the military will not have to pay for it as it also has application for infant hearing screening.

Validity and reliability data were collected using the new Mimosa Acoustics equipment. Data for the validity experiment were collected on 8 people (from 10 people screened) with severe to profound hearing-impairments (who should have no otoacoustic emissions – if they appear to have them, it is artifact). The otoacoustic-emission types were SFOAEs, and TEOAEs (both filtered clicks and chirps). Preliminary analyses showed that there was no artifact at the levels we want to use for testing, but there can be artifact at higher levels, particularly in the linear test mode. Data to determine how to equate the energy level of chirps vs clicks and to determine how well a new stimulus-spectrum calibration works for clicks and chirps were collected on 14 ears (on 12 people). Preliminary analyses indicated that it was more appropriate to equate clicks and chirps in rms than peak SPL and that the spectral calibration developed by Mimosa Acoustics improved the reliability of the measurements. Data to determine test-retest reliability of SFOAEs and TEOAEs (both filtered clicks and chirps) were collected in 59 ears (from 33 people).

We developed a way to measure synchronized spontaneous otoacoustic emissions (SOAEs) on our new Mimosa Acoustics equipment. It is more sensitive (and just as fast) at detection of SOAEs than our older, commercially available EOAE system. This is very important because it has become apparent that the location of these SOAEs needs to be known for the interpretation of SFOAEs as well as for other emission types.

COMMAND HISTORY

Fiscal Year 2003

Part 2

2. Special Topics as applicable

(1) Statistics on major functions.

During the annual NDIA Conference held this year on 24-26 September 2003 on Submarine Base New London, NSMRL was given the honor to host a new technical session entitled "Human Systems Integration for Submarines." Our distinguished speakers included:

RDML Michael Tracy, USN, Director, Submarine Warfare Division (N77)
CDR Charles Sykora, USN, Commanding Officer, USS DALLAS (SSN700)
Mr. Waldemar H. Koscinski, Head, Acquisition Support Group, Human Systems
Integration Directorate, NAVSEA 03
CAPT Arnold Lotring, USN, Commanding Officer, Center for Submarine Learning
CAPT Frank Caldwell, USN, Commander, Submarine Development Squadron Twelve
CAPT Edward Woods, MC, USN, Naval Special Warfare Command Medical Officer

NSMRL staff speakers were:

CDR Wayne Horn, MC, USNR
Dr. Edward Cudahy
LT Jeff Dyche, MSC, USNR

(2) Number of military and civilian personnel onboard in FY03.

Military Officer	9
Military Enlisted	7
Civilian Professional	8
Civilian Supporting	<u>11</u>
Subtotal	35

Contracted	
Geo-Centers	9
IPAs	<u>4</u>

TOTAL	48
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(3) Major command problems faced during the year. NONE

COMMAND HISTORY
Fiscal Year 2003
Part 3

3. List of Supporting Documents:

(1) NSMRL Reports

Shobe, K. Navy Voice Interactive Device: Shipboard Signal Analysis Report. NSMRL Memo Report #03-01, February 2003.

Russotti, J.S. Sonar Operator Active Noise Reduction Insert-Earphone: Prototype Preliminary Test and Evaluation. NSMRL Technical Report #1225, February 2003.

Miller, J., Dyche, J., Cardenas, R., and Carr, W. Effects of Three Watchstanding Schedules on Submariner Physiology, Performance, and Mood. NSMRL Technical Report #1226, March 2003.

Wolgemuth, K. S., and Perkins, E. M. Command History Fiscal Year 2001. NSMRL Special Report #03-01, March 2003.

Santoro, T. Kieras, D. and Pharmer, J. Verification and Validation of Latency and Workload Predictions for a Team of Humans by a Team of Computational Models. NSMRL Technical Report #1227, May 2003.

Lamb, J. C., and Perkins, E. M. Command History Fiscal Year 2002. NSMRL Special Report 03-02, July 2003.

Norfleet, W., and Horn, W. G. Carbon Dioxide Scrubbing Capabilities of Two New Non- Powered Technologies. NSMRL Technical Report #1228, August 2003.

Wolgemuth, K. S., Marshall, L., Miller, J. L. Recommendations Regarding the Effects of Audiometric Test-Retest Reliability on the Development of OSHA Standard Threshold Shift Criteria and Recording of Work-Related Material Hearing Loss. NSMRL Memo Report #MR03-02. September 2003.

Shobe, K. Bing, M. Duplessis, C. Dyche, J, Fothergill, D. Horn, W. Lamb, J. Quatroche, A. Watenpaugh, D. Plott, C. Psychological, Physiological, and Medical Impact of the Submarine Environment on Submariners with Application to Virginia Class Submarines. NSMRL Technical Report #1229, October 2003.

Shobe, K. Bing, M. Horn, W. Watenpaugh, D. Submarine Quality of Life and Physical Fitness Issues: Addendum to NSMRL Technical Report#1229, Memo Report #03-03, December 2003.

(2) Journal Articles

Santoro, T. P., Kieras, D., and Pharmer, J. Verification and validation of latency workload predictions for a team of humans by a team of GOMS models. **Journal of Underwater Acoustics** (in press).

Lapsley Miller, J. A., Marshall, L., and Heller, L. Permanent and temporary noise-induced changes in transient-evoked and distortion-product otoacoustic emissions in a longitudinal study in humans. **International Journal of Audiology** (in press).

Burroughs, S. M., Wothe, D. J., Bing, M. N., and McIntyre, M. D. Another perspective on workplace deviance: An evaluation of a peer-report based measure. **Journal of Applied Psychology** (in press).

Dyche, J. Psychological Science Onboard a Submarine. **APS Observer** October 2003..

Bing, M.N., Burroughs, S. M., Davison, H. K., Green, P. D., and James, L. R. The integration model of personality assessment for aggression: Implications for personnel selection and predicting deviant workplace behavior. **Personnel Psychology** (in press).

Bing, M. N., Whanger, J. C., Davison, H. K., and VanHook, J. B. Incremental validity of the frame-of-reference effect in personality scale scores: A replication and extension. **Journal of Applied Psychology** (in press).

Santoro, T. P., Kieras, D., and Pharmer, J. Verification and validation of latency and workload predictions for a team of humans by a team of GOMS models. **U.S. Navy Journal of Underwater Acoustics** (in press -also published as NSMRL Technical Report #1227).

Bealer, J. R., Wolgemuth, K., Rovig, G., and Page, J. C. An initial look at a centralized electronic database and hearing loss within the United States Navy. **Military Medicine** (in press).

Fothergill, D., Sims, J., and Curley, M. Effects of a neoprene wetsuit hood on low- frequency underwater hearing thresholds. **Journal of the Acoustical Society of America**.(in press).

Cudahy, E. A., Schwaller, D., Fothergill, D., and Wolgemuth, K. Underwater Loudness for Tones: Duration Effects. Presented at the 145th Scientific Meeting of the Acoustical Society of America, May 2003. **Journal of the Acoustical Society of America**, 113(4), pg 2292,2003.

Horn, W. SURVIVEX 2003, Exercise Tests Disabled Submarine Survival. Fall 2003. **Undersea Warfare**.

(3) Presentations

Wolgemuth, K. The USS MONITOR Recovery Project: U.S. Navy Dives Into History. Waterford Public Library, Waterford, CT, 13 November 2002.

Dyche, J. A New Submarine Watchstanding Schedule: Laboratory and At-Sea Trials. Bradley Hospital Sleep Research Center, Providence, RI, 17 December 2002.

Dyche, J. Sleep Needs in Adolescents: A Navy Boot Camp Rationale. State School Superintendents Meeting, East Lyme, CT, 10 January 2003.

Shobe, K. Situation Awareness Measurement During Operational Testing. Military Operations Research Society, Quantico, V A, 10-12 June 2003.

Watenpaugh, D. Degassed Liquids to Prevent/Treat Decompression Sickness. Perfluorocarbons in DCS Workshop, Naval Medical Research Center, Silver Spring, MD, 9 April 2003.

Cudahy, E. A., Schwaller, D., Fothergill, D., and Wolgemuth, K. Underwater Loudness for Tones: Duration Effects. Acoustical Society of America, Nashville, TN, 1 May 2003.

Bing, M. N., and Eisenberg, K. L. The Prediction and Prevention of Attrition in U.S. Navy Submarines. DoD Human Factors Engineering Technical Advisory Group, Augusta, GA, 12-15 May 2003.

Dyche, J. Submarine Watchstanding in a Shore Based Laboratory: Behavioral and Psychological Outcomes. Asia Pacific Military Medicine Conference, Bangkok, Thailand, 13 May 2003.

Santoro, T. P. Audio Technology and Management in Modern Navy Systems. ONR Code 342 Workshop, Rensselaer Polytechnic Institute, Troy, NY, 4-6 June 2003.

Shobe, K., and Murray, L. Situation Awareness Measurement During Submarine Operational Testing. Military Operations Research Society Symposium, Quantico, V A, 10-12 June 2003.

Miller, J. C., and Dyche, J. Effects of Three Watchstanding Schedules on Submariner Sleep Physiology. Association of Professional Sleep Societies (APSS) Annual Convention, 3-8 June 2003.

Shobe, K., and Murray, L. Situation Awareness Measurement During Submarine Operational Testing. Human Systems Integration Symposium, Tysons Corners, V A, 23- 25 June 2003.

Bing, M. and Eisenberg, K. The Development and Validity of the Submarine Attrition Risk Scale (SARS). IPMAAC, Baltimore, MD, 22-25 June 2003.

Fothergill, D., and White, D. Human Factors Evaluation of Closed Circuit O2 Rebreathers for Hyperbaric Oxygen Treatment. Undersea and Hyperbaric Medical Society Meeting, Quebec, Canada, 19-21 June 2003.

Wolgemuth, K. USS MONITOR Recovery Project Year 3: Gun Turret Recovery July- August 2002. Informal slide presentation at the Ledyard, CT, Rotary Club, 24 July 2003

Watenpugh, D. Degassed Liquids to Prevent/Treat Decompression Sickness. Wilderness Medical Society Meeting, Whistler, British Columbia, Canada, 9-13 August 2003.

Horn, W. Benton, P. A Trial of Survival Capabilities Aboard a Simulated Disabled Submarine. SAMAP Conference, Emden, Germany. October 2003.

Fothergill, D. Improving Human Performance in the Undersea Environment. INDO-US Joint Workshop on Life Sciences Enhancing Human Performance in Military Environments, New Delhi, India 10-12 November 2003.

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Naval Submarine Medical Research Laboratory Groton, CT

The United States Submarine service has a long and proud tradition of developing and operating with leading edge technologies. The Naval Submarine Medical Research Laboratory (NSMRL) is a major contributor to integrating these technologies into submarine crew operations. NSMRL is DoD's Center for Undersea Biomedical Research. The laboratory's mission is to protect the health and enhance the performance of warfighters through submarine, diving and surface biomedical research solutions. Established in World War II to conduct mission critical studies in night vision, sonar sound discrimination, and personnel selection, NSMRL continues to serve the fleet by taking the lead in undersea human factors, sensory sciences and operational medicine.

Located on Submarine Base New London, Groton, CT, NSMRL researchers have access to three submarine squadrons in Submarine Group Two; the Navy Submarine School; the Naval Submarine Support Facility; Naval Undersea Medical Institute; and the Electric Boat Division of General Dynamics, which builds the nation's submarines. The laboratory is staffed by a diverse group of psychologists, audiologists, physicians, physiologists, and electrical, biomedical and nuclear engineers. Several colleges and universities are located in the same area, including the US Coast Guard Academy, Connecticut College, and the University of Connecticut.

NSMRL's accomplishments continue to be many and varied, and include scientifically based recommendations for submarine rescue procedures, submarine atmosphere limits, waivers for clinical medical conditions, advanced sonar system capabilities, diver/sonar safe distances, and symbology for visual displays.

NSMRL Scientists and Divers Touched by History



A research team of scientists and divers dove into history when they collected research data as part of a preservation project for the USS ARIZONA memorial in Pearl Harbor, HI. The team worked with Mobile Diving and Salvage Unit 1 and the National Park Service, taking underwater noise measurements of a new hydraulic tool designed to remove samples of the battleship's hull for metallurgical analysis. The research team had two jobs to do, collect underwater noise levels as part of NSMRL's two-year comprehensive in-water noise survey project and determine the on-site permissible noise exposure level for the divers. Team members also performed working dives to assist in completion of the

preservation project. This is a good example of Navy scientists and divers working side-by-side with working dive lockers and other government agencies to accomplish both research data collection and provide direct fleet support.

Diving and Environmental Simulation Department

- Diving and Environmental Simulation department focuses on ways to optimize the safety and performance of Navy divers by investigating diver performance for a variety of environmental factors including sound exposure, thermal stress, and breathing gas conditions. Underwater noise can impact a diver through damage to hearing and internal organs, such as the lung and brain. Applied research includes reducing workplace hazards, providing underwater noise-protection tools and developing underwater force protection. A critical part of the program is the on-going direct fleet support regarding guidelines for operational limits due to underwater noise. These guidelines are developed directly from the basic research data collected by the laboratory.

Submarine Medicine & Survival Systems Department

- Submarine Medicine researchers focus on ways to optimize the health and job performance of undersea warfighters and reduce attrition and health impact due to psychological and physical conditions. The department includes the NAVSEA-sponsored Submarine Atmosphere Health Assessment Program.
- Survival Systems researchers conduct basic and applied research and development in the biomedical and bioengineering aspects of submarine casualties by developing equipment, procedures and guidance to optimize submarine disaster survival. The researchers serve as subject-matter experts on submarine rescue and escape for the operational fleet, policy makers and industry.

Human Performance Department

- Hearing Conservation focuses on ways to identify the early stages of noise-induced damage to the human ear to prevent noise-induced hearing loss. Current research involves the evaluation of new methods for evoking otoacoustic emissions, an objective test that is thought to be sensitive to the early stages of noise-induced hearing loss (NIHL) and a measure of susceptibility to NIHL. The team's approach is to evaluate these methods both in the laboratory for validity, reliability, and sensitivity to temporary noise-induced changes; and in the field with noise-exposed at-risk personnel for detecting the early stages of permanent noise-induced changes.
- Information Processing and Display scientists focus on ways to optimize the quality of information presented to Navy operators (e.g., officer of the deck, fire control and submarine sonar consoles) by decreasing operator workload and improving the human-machine interface. Displays that help the operator separate desired from undesired information will increase situational awareness; reduce workload; and improve the identification, classification and tracking of signals of interest.

Achievements:

- | | |
|--|--|
| • Sea Lab I undersea habitat project | • Studies of nitrogen narcosis |
| • Development of the International Orange Color (Air-Sea Rescue Red) | • Effects of atmospheric constituents on health and performance in enclosed environments |
| • Disabled Submarine Escape and Rescue project | • Pressurized Submarine Rescue Manual |
| • Saturation diving and decompression tables | • Data-based medical qualification policies |
| • Hearing conservation in noisy environments | • Farnsworth lantern for screening color vision |
| • Safe exposure guidance for personnel in the presence of intense low and high frequency sonars. | • Underwater acoustic signal discrimination and classification |

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